

The vascular flora of the Apuan Alps (Tuscany, Central Italy)

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Abstract

We present an updated and critically revised list of the vascular flora occurring in the Apuan Alps (Tuscany), a renowned area of high naturalistic interest. The list is based on a literature survey, herbarium and field studies. The Apuan Alps host an established flora of 1,987 specific and subspecific taxa (including 106 naturalized and 24 invasive aliens), 76 casual aliens and 27 hybrid taxa. Three taxa are new for Tuscany: *Anthyllis vulneraria* subsp. *pulchella*, *Chaenomeles speciosa* (casual alien), and *Thalictrum minus* subsp. *saxatile*, while *Helianthemum oelandicum* subsp. *alpestre* is excluded from the regional flora; 47 taxa are new for the study area (31 native, 16 alien). Concerning old records, 168 (158 native, four hybrid, and six casual alien taxa) were not confirmed, albeit considered reliable. Moreover, we considered 10 taxa as locally extinct, 44 as doubtfully occurring, and 14 as reported by error. Life forms suggest a transitional situation between a Mediterranean bioclimatic context and a more distinctly subcontinental one. Regarding the chorological spectrum, there is a clear prevalence of species with a distribution centered in the Eurosiberian Region, with a biogeographically relevant component represented by 152 taxa, among which 93 Italian endemics (30 of them narrowly endemic to Apuan Alps). Based on species-area relationship, the number of native taxa exceeds the one expected, while the number of alien taxa is lower than expected. This positions the area as objectively rich in terms of its flora and of high natural value.

Keywords

Alien species, biodiversity, endemics, floristic data, phytogeography

*This work is dedicated to Dino Marchetti and Giuseppe Trombetti,
profound connoisseurs of the Apuan Alps*

Introduction

A flora is a basic source of information for biogeographical, ecological and evolutionary studies (Peruzzi 2018; D’Antraccoli et al. 2022; Bartolucci et al. 2024), so that floristic inventories are crucial to provide suitable data for decision-making processes in biodiversity conservation and landscape planning, either in urban (Peruzzi 2023; Peruzzi et al. 2025) or more natural (Carta et al. 2018; Gestri et al. 2023) areas.

The Apuan Alps, due to their geomorphological and biogeographical features, have always attracted the interest of botanists, since the origins of Botany itself (Soldano 2004). However, the first comprehensive flora of the area was published by Pellegrini (1942), later updated by E. Ferrarini (18 April 1919–19 September 2002) and collaborators (Ferrarini and Marchetti 1994; Ferrarini et al. 1997; Ferrarini 2000). In both cases, the floristic lists covered a broader area, including Lunigiana and the coastal portion of the Massa area in the case of P. Pellegrini (18 July 1867–31 May 1957), or the Apuan Alps and the entire adjacent coastal portion in the case of Ferrarini, named by him “Apuan Region”. Therefore, a floristic list focused solely on the Apuan Alps does not exist, despite a lot of recent taxonomic and floristic literature was published in the last decades (e.g., Di Fazio et al. 2004; Vaira et al. 2005; Pacifico et al. 2007; Lazarević et al. 2015; Marchetti 2018; Bartolucci et al. 2019, 2020, 2021, 2022a, 2022b; Peruzzi et al. 2019, 2020, 2021, 2023; Conti et al. 2021; Galasso et al. 2020; Trombetti 2020; for a full account of the literature available, see the Suppl. material 1). After more than twenty years since the last synthesis, we believe it is time to produce an updated and critically revised list of the vascular flora.

Materials and methods

Study area

We referred to the territorial area most closely related to the Apuan Alps, according to Montagna et al. (1979). The area under examination (Fig. 1; 1,056 km²) extends from the northwest, in the province of La Spezia, to the southeast, in the province of Pisa, both of which are hilly regions. In the middle, the main chain develops, consisting of steep mountains towards the coast, in the province of Massa–Carrara, with various lateral branches and inland extensions in the province of Lucca. The area is naturally delimited by the base of the coastal hills between the Magra and Serchio rivers, and by the Serchio river, the Magra river, and its tributary Aulella. On the coastal side, there are the basins of the Carrione, Frigido, Serra, and Camaiore streams, which flow into

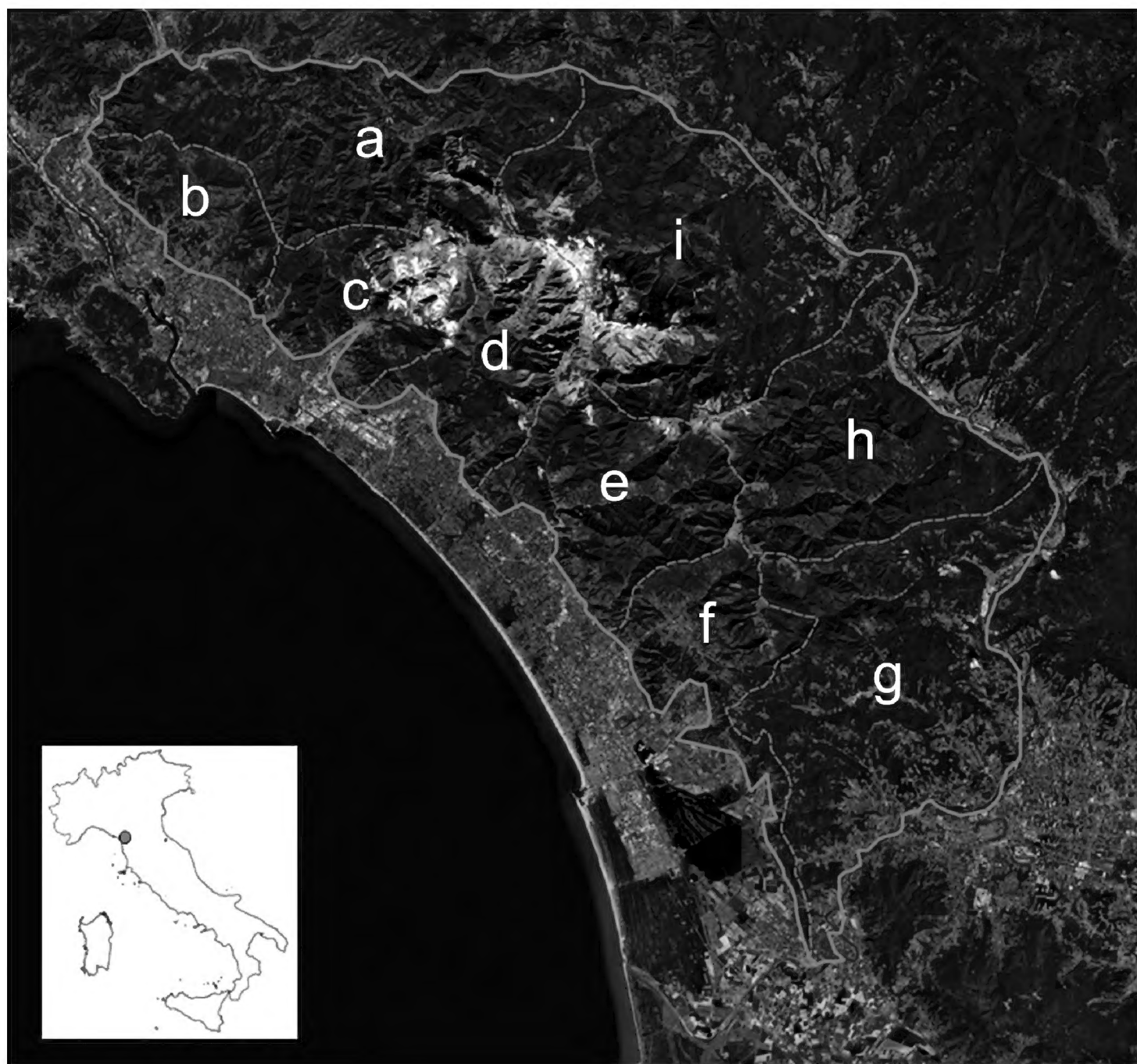


Figure 1. The study area related to the Apuan Alps, covering 1,056 km², is mostly located in the provinces of Lucca and Massa-Carrara in the northwestern part of Tuscany. It also includes the 9 Operational Geographic Units (OGUs) used as reference points in the research: Apuan portion of middle Lunigiana, Massa-Carrara, Tuscany (**a**), Apuan portion of coastal Lunigiana, La Spezia/Liguria and Massa-Carrara/Tuscany (**b**), hills and mountains above Carrara, Massa-Carrara, Tuscany (**c**), hills and mountains above Massa, Massa-Carrara, Tuscany (**d**), hills and mountains above Versilia, Lucca, Tuscany (**e**), coastal hills and mountains of southern Apuan Alps, Lucca/Pisa, Tuscany (**f**), Apuan portion of the hills and mountains above Lucca, Tuscany (**g**), Apuan portion of lower Garfagnana, Lucca, Tuscany (**h**), Apuan portion of higher Garfagnana, Lucca, Tuscany (**i**).

the Ligurian Sea. On the inland side, there are the valleys of the Magra and Serchio rivers. Both of these rivers flow into the Ligurian Sea. The two valleys extend in opposite directions and meet at the Foce dei Carpinelli, which separates the Apuan Alps from the Apennines.

We subdivided the study area in nine Operational Geographic Units (OGUs hereafter), based on the main watershed lines (Fig. 1): Apuan portion of middle Lunigiana, Massa-Carrara, Tuscany (**a**), Apuan portion of coastal Lunigiana, La Spezia/Liguria and Massa-Carrara/Tuscany (**b**), hills and mountains above Carrara, Massa-Carrara,

Tuscany (c), hills and mountains above Massa, Massa-Carrara, Tuscany (d), hills and mountains above Versilia, Lucca, Tuscany (e), coastal hills and mountains of southern Apuan Alps, Lucca/Pisa, Tuscany (f), Apuan portion of the hills and mountains above Lucca, Tuscany (g), Apuan portion of lower Garfagnana, Lucca, Tuscany (h), and Apuan portion of higher Garfagnana, Lucca, Tuscany (i).

The core portion of the study area, thanks to its naturalistic relevance, is a Regional Natural Park instituted by Regione Toscana since 1985 (<https://www.parks.it/parco.alpi.apuane/map.php>), although its extension was reduced from the original 540 km² to 206 km² in 1997 (Regional Law 65/1997) to “preserve” the worldwide well-known marble quarries. The protected area also includes a number of Special Areas for Conservation (SACs) according to the Habitats Directive of the European Union: “Monte Sagro”, “Monte Castagnolo”, “Monte Borla - Rocca di Tenerano”, “Valli glaciali di Orto di Donna e Solco d’Equi”, “Monte Sumbra”, “Valle del Serra - Monte Altissimo”, “Valle del Giardino”, “Monte Croce - Monte Matanna”, “Monte Tambura - Monte Sella”, “Monte Corchia - Le Panie”.

The mountains are typically rugged and jagged, and the highest peak is Monte Pisanino (1947 m a.s.l.). On geological grounds, the central portion of the Apuan Alps is dominated by Tuscan metamorphic units (mostly limestones and dolomites), surrounded by the Tuscan Nappe (Frassi et al. 2022). Thanks to these peculiarities, the Apuan Alps are also recognized as an UNESCO Global Geopark since 2012. Due to the proximity to the coast of these relatively high mountains, this is one of the rainiest areas in Italy, with more than 3000 mm/year (Giannecchini 2006).

Most of the territory show typically temperate vegetation series: the Apuan hypsophilic series of *Carex sempervirens* Vill. grasslands (*Seslerio tenuifoliae-Carici sempervirentis sigmetum*) and the Apennine eutrophic subacidophilic series of beech (*Cardamino heptaphyllae-Fago sylvaticae sigmetum*) at higher elevations; the Apuan neutrobasiphilic series of black hornbeam (*Roso caninae-Ostryo carpinifoliae sigmetum*) and the north-western acidophilus Apennine series of durmast oak (*Physospermo cornubensis-Quercu petraeae sigmetum*) at lower elevations. The only exception to this general figure are the hills located in the extreme southern portion of the Apuan Alps (the so-called “Monti d’Oltre Serchio”), that belong to the Mediterranean Italian peninsular neutrobasiphilic series of holm oak (*Cyclamino hederifolii-Quercu ilici sigmetum*) (De Dominicis et al. 2010a, 2010b).

Floristic inventory

The update and revision work involved a critical analysis of the literature, a review of herbarium samples (mainly in APP, FI, PI, ROV, and SIENA), and the integration of these data with the observations included in Wikiplantbase #Toscana (Peruzzi and Bedini 2013–) and with 2717 original new records from the authors, similar to what was already done for the vascular flora of the province of Lucca (Pierini and Peruzzi 2014). The resulting list was contrasted with a list of taxa deriving from the records stored in iNaturalist, a useful tool in floristic research (Khapugin et al. 2021; White et

al. 2023). Records of new taxa/localities were then individually checked for reliability, before inclusion in the floristic inventory.

Nomenclature was aligned with the two recently published checklists of the native (Bartolucci et al. 2024) and alien (Galasso et al. 2024) vascular flora of Italy, and with their updates made available through the Portal to the Flora of Italy (<https://dryades.units.it/floritaly/>) (Martellos et al. 2020). Families of flowering plants were organized following the latest phylogenetic classification of the APG IV (2016). Taxa were considered as not confirmed if no records were available after 1960. Aliens recorded only historically (i.e. not confirmed) were automatically considered as casual aliens at local level, irrespective of the regional alien status in Tuscany (Galasso et al. 2024). Life forms and chorotypes were derived from Pignatti (2017a, 2017b, 2018) for all taxa, excluding cryptogenic species, cultivated and casual taxa, and hybrids. The retrieved chorotypes were compared and adjusted based on the distribution data available on Euro+Med database (2024–) and POWO (2024–). Chorotypes were then included in the floristic regions proposed by Arrigoni (1983) for Europe. Information on the Italian endemics was retrieved from Bartolucci et al. (2024) and Peruzzi et al. (2014, 2015), while information about non-endemic taxa described from Apuan Alps was derived from Peruzzi et al. (2019). We also obtained the available regional IUCN Red List categories from the Red Lists for the Italian Flora (Rossi et al. 2013, 2021; Orsenigo et al. 2021).

The expected number (S) of entire, native, and alien taxa occurring in the study area (A) were calculated using Arrhenius' species-area relationship $S = cA^z$, and using the c (241.2, 245.2, and 10.1 for the entire, native and alien taxa, respectively) and z (0.281, 0.263, and 0.404 for entire, native and alien taxa, respectively) coefficients empirically calculated for the floristic richness of Italy by D'Antraccoli et al. (2024).

Results

The complete floristic inventory of the Apuan Alps is reported in the Suppl. material 1. The expected numbers for the entire established flora, native, and alien taxa according to the species-area relationship are 1,705, 1,630, 168, respectively.

The established flora consists of 1,987 specific and subspecific taxa, including 130 alien (106 naturalized, 24 invasive) and 158 not recently confirmed taxa. Additionally, there are 27 hybrids (four not confirmed) and 76 casual aliens (six not confirmed). Moreover, we considered 10 taxa as locally extinct, 44 as doubtfully occurring, and 14 as reported by error.

The most represented families are Asteraceae (270), Poaceae (181), Fabaceae (162), Rosaceae (83), Brassicaceae (77), Caryophyllaceae (79), Apiaceae (72), Orchidaceae (69), Cyperaceae and Plantaginaceae (54), while the most represented genera are *Hieracium* (43), *Carex* (35) and *Trifolium* (35), *Festuca* (22), *Euphorbia* and *Veronica* (20), *Lathyrus* (18), *Allium* (16), *Vicia* (16), *Alchemilla* and *Ranunculus* (15).

The results concerning the numbers of the entire established flora for each OGU (Fig. 1) are summarized in Table 1.

Table 1. Operational Geographic Units, their extension (area), expected and confirmed numbers of the entire established flora, of not confirmed historical, and doubtful records. The OGU showing the observed number of taxa higher than expected are highlighted in bold.

OGU	Description	Area (Km ²)	Expected established flora	Confirmed established flora	Historical records	Doubtful records
a	Apuan portion of middle Lunigiana	158.23	1,000	1,040	147	7
b	Apuan portion of coastal Lunigiana	48.59	718	731	95	1
c	hills and mountains above Carrara	66.78	785	978	149	7
d	hills and mountains above Massa	72.44	803	1,240	137	7
e	hills and mountains above Versilia	96.95	872	1,111	174	9
f	coastal hills and mountains of southern Apuan Alps	72.58	804	741	66	0
g	Apuan portion of the hills and mountains above Lucca	207.76	1,080	777	199	4
h	Apuan portion of lower Garfagnana	128.22	943	778	22	1
i	Apuan portion of higher Garfagnana	204.88	1,076	1,108	66	16

Three new taxa were recorded from Tuscany, along with 47 taxa (31 native, 16 alien) newly reported for the Apuan Alps (Table 2). On the contrary, *Helianthemum oelandicum* (L.) Dum.Cours. subsp. *alpestre* (Jacq.) Ces. is excluded from the regional flora (see the Suppl. material 1 for more details). The biogeographically relevant component of the flora is represented by 152 taxa (Table 3), among which 93 Italian endemics (30 of them narrowly endemic to Apuan Alps).

Discussion

Even excluding recently unconfirmed taxa, the 1,832 confirmed taxa of the established flora exceed the expected number (1,705 taxa). When considering only the native flora (1,702 confirmed taxa), the observed number also exceeds the expected one (1,630 taxa), while the number of confirmed alien taxa (130) is lower than expected (168). Concerning the single OGU, the six corresponding to the central and northern portion of Apuan Alps show numbers higher than expected (much higher in OGU “c”: +25%, OGU “d”: +54%, OGU “e”: +27%) (Table 1). On the contrary, the three poorest OGU, corresponding to the southern portion of Apuan Alps, show numbers lower than expected, based on their extension. However, while the OGU “f” is more or less in line with predictions if historical records are considered, the OGU “g” and especially “h” remain below the expected values, even when summing the historical and doubtful records to the confirmed established flora. This is not particularly surprising, given that the southern portion of the Apuan Alps have mountains of lower mean elevation and in general lower environmental variability, although Di Musciano et al. (2021) showed decreasing species richness with increasing elevation, based on the elevational ranges reported for each species by Ferrarini and Marchetti (1994), Ferrarini et al. (1997), and Ferrarini (2000) in their flora.

Table 2. Floristic novelties for Apuan Alps after this study.

New records for Tuscany – 3 taxa (2 native, 1 alien)	
<i>Anthyllis vulneraria</i> L. subsp. <i>pulchella</i> (Vis.) Bornm.	
<i>Chaenomeles speciosa</i> (Sweet) Nakai (casual alien)	
<i>Thalictrum minus</i> L. subsp. <i>saxatile</i> (Moritzi) Ces.	
New records for Apuan Alps – 47 taxa (31 native, 16 alien)	
<i>Agrostis gigantea</i> Roth subsp. <i>gigantea</i>	
<i>Allium cepa</i> L. (casual alien)	
<i>Anthoxanthum nipponicum</i> Honda	
<i>Arceuthobium oxycedri</i> (DC.) M.Bieb.	
<i>Artemisia arborescens</i> (Vaill.) L.	
<i>Bellardia trixago</i> (L.) All.	
<i>Cerastium tomentosum</i> L. (naturalized alien)	
<i>Crocus ×luteus</i> Lam. ‘Golden Yellow’ (casual alien)	
<i>Crupina vulgaris</i> Cass.	
<i>Dasyphyrum villosum</i> (L.) P.Candargy	
<i>Draba verna</i> L. subsp. <i>verna</i>	
<i>Epipactis neglecta</i> (Kümpel) Kümpel	
<i>Eragrostis pectinacea</i> (Michx.) Nees (naturalized alien)	
<i>Ficaria verna</i> Huds. subsp. <i>ficariiformis</i> (F.W.Schultz) B.Walln.	
<i>Hemerocallis fulva</i> (L.) L. (naturalized alien)	
<i>Ipomoea indica</i> (Burm.) Merr. (naturalized alien)	
<i>Iris pallida</i> Lam. (casual alien)	
<i>Lagurus ovatus</i> L.	
<i>Lamium hybridum</i> Vill.	
<i>Lathyrus hirsutus</i> L.	
<i>Leucanthemum ircutianum</i> DC. subsp. <i>ircutianum</i>	
<i>Lotus edulis</i> L.	
<i>Medicago intertexta</i> (L.) Mill.	
<i>Morus alba</i> L. (casual alien)	
<i>Oenothera fallacoides</i> Soldano & Rostański (casual alien)	
<i>Ornithogalum etruscum</i> Parl. subsp. <i>umbratile</i> (Tornad. & Garbari) Peruzzi & Bartolucci	
<i>Orobancha artemisiae-campestris</i> Vaucher ex Gaudin	
<i>Papaver setigerum</i> DC.	
<i>Parthenocissus inserta</i> (A.Kern.) Fritsch (naturalized alien)	
<i>Phleum nodosum</i> L.	
<i>Phleum rhaeticum</i> (Humphries) Rauschert	
<i>Polygala nicaeensis</i> Risso ex W.D.J.Koch subsp. <i>peninsularis</i> Arrigoni	
<i>Prunella ×intermedia</i> Link	
<i>Prunus persica</i> (L.) Batsch (casual alien)	
<i>Puccinellia fasciculata</i> (Torr.) E.P.Bicknell	
<i>Reynoutria bohemica</i> Chrtek & Chrtková (invasive alien)	
<i>Rosa pouzinii</i> Tratt.	
<i>Sagina micropetala</i> Rauschert	
<i>Silene viridiflora</i> L.	
<i>Stellaria ruderalis</i> M.Lepší, P.Lepší, Z.Kaplan & P.Koutecký	
<i>Tragopogon eriospermus</i> Ten.	
<i>Tragopogon orientalis</i> L.	
<i>Tripleurospermum inodorum</i> (L.) Sch.Bip.	
<i>Vitis labrusca</i> L. (casual alien)	
<i>Vitis rupestris</i> Scheele (naturalized alien)	
<i>Vitis ×instabilis</i> Ardenghi, Galasso, Banfi & Lastrucci (naturalized alien)	
<i>Vitis ×koberi</i> Ardenghi, Galasso, Banfi & Lastrucci (naturalized alien)	

Table 3. Biogeographically relevant taxa in the vascular flora of Apuan Alps. A total of 152 taxa is of high biogeographical interest, because reaching in the Apuan Alps the limit of their range (39 taxa) or showing a more or less restricted range (113 taxa).

Taxa reaching in the Apuan Alps the limit of their range – 40 taxa
<i>Achillea distans</i> Waldst. & Kit. ex Willd. subsp. <i>tanacetifolia</i> (Fiori) Janch. (disjunct)
<i>Asplenium ruta-muraria</i> L. subsp. <i>dolomiticum</i> Lovis & Reichst. (disjunct)
<i>Horminum pyrenaicum</i> L. (disjunct)
<i>Hymenophyllum tunbrigense</i> (L.) Sm. (disjunct)
<i>Lactuca ramosissima</i> (All.) Boreau (disjunct)
<i>Vandenboschia speciosa</i> (Willd.) G.Kunkel (disjunct)
<i>Aposeris foetida</i> (L.) Less. (southern)
<i>Aquilegia atrata</i> W.D.J.Koch (southern)
<i>Aruncus dioicus</i> (Walter) Fernald (southern)
<i>Centaurea nervosa</i> Willd. subsp. <i>nervosa</i> (southern)
<i>Doronicum pardalianches</i> L. (southern)
<i>Dryocallis rupestris</i> (L.) Soják (southern)
<i>Empetrum hermaphroditum</i> Hagerup (southern)
<i>Euphrasia alpina</i> Lam. subsp. <i>alpina</i> (southern)
<i>Gentiana clusii</i> E.P.Perrier & Sonjeon (southern)
<i>Geranium phaeum</i> L. (southern)
<i>Heracleum pyrenaicum</i> Lam. subsp. <i>pollinianum</i> (Bertol.) F.Pedrotti & Pignatti (southern)
<i>Hieracium glabratum</i> Hoppe ex Willd. subsp. <i>pseudoflexuosum</i> Nägeli & Peter (southern+disjunct)
<i>Hieracium pilosum</i> Schleich. ex Froel. subsp. <i>comatulum</i> (Nägeli & Peter) Gottschl. (southern+disjunct)
<i>Homogyne alpina</i> (L.) Cass. (southern)
<i>Hypericum coris</i> L. (southern)
<i>Knautia maxima</i> (Opiz) J.Ortmann subsp. <i>maxima</i> (southern)
<i>Omphalodes verna</i> Moench (southern)
<i>Pimpinella saxifraga</i> L. subsp. <i>alpina</i> (Host) Nyman (southern)
<i>Rhododendron ferrugineum</i> L. (southern)
<i>Saxifraga aspera</i> L. (southern)
<i>Saxifraga exarata</i> Vill. subsp. <i>pseudoexarata</i> (Braun-Blanq.) D.A.Webb. (southern)
<i>Scabiosa lucida</i> Vill. subsp. <i>lucida</i> (southern)
<i>Scorzoneroides helvetica</i> (Mérat) Holub (southern)
<i>Taraxacum tenuifolium</i> (Hoppe & Hornsch.) W.D.J.Koch (southern+disjunct)
<i>Valeriana saxatilis</i> L. (southern+disjunct)
<i>Woodsia alpina</i> (Bolton) Gray (southern)
<i>Carex macrolepis</i> DC. (western)
<i>Plantago argentea</i> Chaix subsp. <i>liburnica</i> Ravnik (western)
<i>Pseudofumaria alba</i> (Mill.) Lidén subsp. <i>alba</i> (western)
<i>Trinia dalechampii</i> (Ten.) Janch. (western+disjunct)
<i>Alchemilla croatica</i> Gand. (western)
<i>Alchemilla lucida</i> Buser (eastern)
<i>Galanthus reginae-olgae</i> Orph. subsp. <i>reginae-olgae</i> (northern)
<i>Ophioglossum lusitanicum</i> L. (northern)
Range centered in Italy (subendemics) – 20 taxa
<i>Alchemilla alpinula</i> S.E.Fröhner
<i>Artemisia nitida</i> Bertol.
<i>Campanula spicata</i> L. (locally extinct)
<i>Festuca billyi</i> Kerguelén & Plonka
<i>Galium obliquum</i> Vill. (historical record)
<i>Galium rubrum</i> L.
<i>Geranium argenteum</i> L.
<i>Globularia cordifolia</i> L. subsp. <i>cordifolia</i>
<i>Hieracium porrifolium</i> L. subsp. <i>porrifolium</i>
<i>Hieracium predilense</i> (Nägeli & Peter) Zahn
<i>Hieracium tomentosum</i> L. subsp. <i>tomentosum</i>

Hieracium valdepilosum Vill.
Leucanthemum coronopifolium Vill. subsp. *ceratophylloides* (All.) Vogt & Greuter
Lophiolepis morisiana (Rchb.f.) Del Guacchio, Bureš, Iamónico & P.Caputo
Luzula pedemontana Boiss. & Reut.
Phyteuma italicum Arv.-Touv.
Pulmonaria hirta L.
Ranunculus boreoapenninus Pignatti
Salix apennina A.K.Skvortsov
Sedum monregalense Balb.

Taxa endemic to Italy and Sardinia-Corsica – 7 taxa

Arenaria bertolonii Fiori & Paol.
Digitalis micrantha Roth
Euphorbia hyberna L. subsp. *insularis* (Boiss.) Briq.
Genista desoleana Vals.
Hieracium bernardii Rouy subsp. *bernardii*
Robertia taraxacoides (Loisel.) DC.
Scabiosa holosericea Bertol.

Taxa endemic to Italy – 6 taxa

Brachypodium genuense (DC.) Roem. & Schult.
Crocus biflorus Mill.
Knautia calycina (C.Presl) Guss.
Koeleria splendens C.Presl (historical record)
Linaria purpurea (L.) Mill.
Melampyrum italicum Soó

Taxa endemic to peninsular Italy – 16 taxa

Adenostyles australis (Ten.) Iamónico & Pignatti
Chaerophyllum magellense Ten. (doubtful occurrence)
Colchicum neapolitanum (Ten.) Ten. subsp. *neapolitanum* (historical records)
Erysimum pseudorhaeticum Polatschek
Festuca alfrediana Foggi & Signorini subsp. *ferrariniana* Foggi, Parolo & Gr.Rossi
Festuca puccinellii Parl.
Galium palaeoitalicum Ehrend.
Helictochloa praetutiana (Arcang.) Bartolucci, F.Conti, Peruzzi & Banfi subsp. *praetutiana*
Hieracium grovesianum Arv.-Touv. ex Belli subsp. *grovesianum*
Myosotis decumbens Host subsp. *florentina* Grau (historical record)
Ophrys sphegodes Mill. subsp. *classica* (Devillers-Tersch. & Devillers) Kreutz
Ornithogalum etruscum Parl. subsp. *etruscum*
Ornithogalum etruscum Parl. subsp. *umbratile* (Tornad. & Garbari) Peruzzi & Bartolucci
Polygala nicaeensis Risso ex W.D.J.Koch subsp. *peninsularis* Arrigoni
Ranunculus pollinensis (N.Terracc.) Chiov.
Scabiosa uniseta Savi

Taxa endemic to central-northern Italy – 7 taxa

Aquilegia apuana (Marchetti) E.Nardi
Cardamine apennina Lihová & Marhold
Centaurea arrigonii Greuter
Hieracium bornetii Burnat & Gremli
Ophrys exaltata Ten. subsp. *montis-leonis* (O.Danesch & E.Danesch) Soca
Polygala flavescens DC. subsp. *flavescens*
Tephrosia italica Holub

Taxa endemic to northern Italy – 3 taxa

Anemonoides trifolia (L.) Holub subsp. *brevidentata* (Ubaldi & Puppi) Galasso, Banfi & Soldano
Phyteuma ovatum Honck. subsp. *pseudospicatum* Pignatti
Sesleria pichiana Foggi, Gr.Rossi & Pignotti

Taxa endemic to northern peninsular Italy – 7 taxa

Armeria denticulata (Bertol.) DC.
Carex macrostachys Bertol.
Centaurea aplolepa Moretti subsp. *lunensis* (Fiori) Dostál

Cherleria laricifolia (L.) Iamónico subsp. *ophiolitica* (Pignatti) Iamónico (locally extinct)
Odontarrhena bertolonii (Desv.) Jord. & Fourr. subsp. *bertolonii*
Ophrys sphegodes Mill. subsp. *maritima* (Pacífico & Soca) Kreutz
Sesleria apennina Ujhelyi

Taxa endemic to Apuan Alps and Northern Apennine – 19 taxa

Armeria arenaria (Pers.) F.Dietr. subsp. *marginata* (Levier) Arrigoni
Atadinus glaucophyllus (Sommier) Hauenschild
Carum appuanum (Viv.) Grande subsp. *appuanum*
Cerastium apuanum Parl.
Cirsium bertolonii Spreng.
Globularia incanescens Viv.
Hieracium boreoapenninum Gottschl.
Hieracium toscoemilianum Gottschl.
Leontodon anomalus Ball
Moltkia suffruticosa (L.) Brand subsp. *bigazziana* Peruzzi & Soldano
Polygala carueliana (Benn.) Burnat
Rhinanthus apuanus Soldano
Senecio nemorensis L. subsp. *apuanus* (Tausch) Greuter
Siler montanum Crantz subsp. *apuanum* F.Conti & Bartolucci
Taraxacum aemilianum Foggi & Ricceri
Thesium sommieri Hendrych
Thliphthisa apuana (Fiori) P.Caputo & Del Guacchio
Veronica aphylla L. subsp. *longistyla* (Ball) Arcang.
Viola ferrarinii Moraldo & Ricceri

Taxa endemic to Apuan Alps – 30 taxa

Aquilegia bertolonii Schott
Astrantia pauciflora Bertol. subsp. *pauciflora*
Athamanta cortiana Ferrarini
Biscutella apuana Raffaelli
Centaurea arachnoidea Viv. subsp. *arachnoidea*
Centaurea montis-borlae Soldano
Festuca apuanica Markgr.-Dann.
Hieracium bupleuroides C.C.Gmel. subsp. *tririvicola* Gottschl.
Hieracium chloropsis Gren. & Godr. subsp. *apuanorum* Gottschl.
Hieracium erucopsis Gottschl.
Hieracium glaucum All. subsp. *serenaiae* Gottschl.
Hieracium juengeri Gottschl.
Hieracium montis-florum Gottschl. subsp. *soldanoi* Gottschl.
Hieracium orodoxum Gottschl. subsp. *pseudonaegelianum* Gottschl.
Hieracium picenorum Gottschl. subsp. *falsobifidum* Gottschl.
Hieracium pontiarnense Gottschl.
Hieracium schmidtii Tausch subsp. *marchettii* Gottschl.
Hieracium sparsivestitum Gottschl.
Hieracium squarrosifurcatum Gottschl.
Orobanche apuana Domina & Soldano
Pinguicula apuana Casper & Analdi
Pinguicula mariae Casper
Salix crataegifolia Bertol.
Santolina pinnata Viv.
Silene lanuginosa Bertol.
Silene pichiana Ferrarini & Cecchi
Cirsium ×sagrense Micháľková & Bureš
Dryopteris ×apuana Gibby, S.Jess. & Marchetti
Salix ×marchettii Merli & F.Martini
Sesleria ×tuzsonii (Ujhelyi) Ujhelyi

The most represented life forms are Hemicryptophytes (43%), Therophytes (26%), and Geophytes (15%), followed by Phanerophytes (9%), Chamaephytes (6%), and Hydrophytes (1%). The H/T ratio of 1.67 suggests a transitional situation between a Mediterranean bioclimatic context and a more distinctly subcontinental one. Regarding the chorological spectrum, there is a clear prevalence of species with a distribution centered in the Eurosiberian Region (45%) and a smaller proportion in the Mediterranean region (12%), with a significant component of taxa whose distribution spans both floristic regions (17%). Thirteen percent of the taxa show a broad distribution, and alien species are not particularly numerous (7%), while the stenochorous component is fairly well represented (6%) with 112 taxa, including 92 Italian endemics.

Among the Italian endemics, 19 taxa are exclusive to the Apuan Alps and the nearby northern Apennines, and 30 are exclusive to the Apuan Alps (more than half of which belonging to Asteraceae): *Centaurea arachnoidea* Viv. subsp. *arachnoidea* (Conti et al. 2011), *C. montis-borlae* Soldano (López-Alvarado et al. 2014), *Cirsium* \times *sagrense* Micháľková & Bureš (Micháľková et al. 2023), *Hieracium bupleuroides* C.C.Gmel. subsp. *tririvicola* Gottschl., *H. chloropsis* Gren. & Godr. subsp. *apuanorum* Gottschl., *H. erucopsis* Gottschl., *H. glaucum* All. subsp. *serenaiae* Gottschl., *H. juengeri* Gottschl., *H. montis-florum* Gottschl. subsp. *soldanoi* Gottschl., *H. orodoxum* Gottschl. subsp. *pseudonaegelianum* Gottschl., *H. picenorum* Gottschl. subsp. *falsobifidum* Gottschl., *H. pontiarnense* Gottschl., *H. schmidtii* Tausch subsp. *marchettii* Gottschl., *H. sparsivestitum* Gottschl., *H. squarrosifurcatum* Gottschl. (Gottschlich 2016), and *Santolina pinnata* Viv. (Giacò et al. 2022).

The remaining taxa endemic to Apuan Alps are: *Astrantia pauciflora* Bertol. subsp. *pauciflora* and *Athamanta cortiana* Ferrarini (Apiaceae), *Biscutella apuana* Raffaelli (Brassicaceae), *Silene lanuginosa* Bertol. and *S. pichiana* Ferrarini & Cecchi (Caryophyllaceae), *Dryopteris* \times *apuana* Gibby, S.Jess. & Marchetti (Dryopteridaceae), *Pinguicula apuana* Casper & Ansaldi and *P. mariae* Casper (Lentibulariaceae; De Castro et al. 2016), *Orobanche apuana* Domina & Soldano (Orobanchaceae; Domina and Soldano 2015), *Festuca apuanica* Markgr.-Dann. and *Sesleria* \times *tuzsonii* (Ujhelyi) Ujhelyi (Poaceae), *Aquilegia bertolonii* Schott (Ranunculaceae; Nardi 2015), *Salix crataegifolia* Bertol. and *S.* \times *marchettii* Merli & F.Martini (Salicaceae; Merli and Martini 2017).

In addition, six non-endemic taxa reported in the floristic inventory have been described on material originating from the Apuan Alps: *Anemone millefoliata* Bertol. (\equiv *Pulsatilla alpina* (L.) Delarbre subsp. *millefoliata* (Bertol.) D.M.Moser), *Arabis stellulata* Bertol. (\equiv *Arabis bellidifolia* Crantz subsp. *stellulata* (Bertol.) Greuter & Burdet), *Artemisia nitida* Bertol., *Draba aspera* Bertol., *Heracleum pollinianum* Bertol. (\equiv *Heracleum pyrenaicum* Lam. subsp. *pollinianum* (Bertol.) F.Pedrotti & Pignatti), and *Verbascum densiflorum* Bertol. (Peruzzi et al. 2019).

Among the taxa confirmed for the study area, 141 are included in the Red List of the Italian Flora (Rossi et al. 2013, 2021; Orsenigo et al. 2021): 93 were assessed as Least Concern, 16 as Data Deficient (among which the locally endemic *Hieracium* species and *Sesleria* \times *tuzsonii*), 8 as Near Threatened (*Aquilegia bertolonii*, *Epipactis palustris* (L.) Crantz, *Fritillaria montana* Hoppe ex W.D.J.Koch, *Galanthus reginae-olgae* Orph. subsp. *reginae-olgae*, *Gladiolus palustris* Gaudin, *Oenanthe fistulosa* L.,

Pinguicula apuana, and *Salix crataegifolia*), 4 as Vulnerable (*Aira provincialis* Jord., *Bellevalia trifoliata* (Ten.) Kunth, *Brassica montana* Pourr., and *Centaurea montisborlae*), 7 as Endangered (*Arceuthobium oxycedri* (DC.) M.Bieb., *Cardamine apennina* Lihová & Marhold, *Euphorbia hyberna* L. subsp. *insularis* (Boiss.) Briq., *Herminium monorchis* (L.) R.Br., *Spiranthes aestivalis* (Poir.) Rich., *Hydrocotyle vulgaris* L., and *Lysimachia tenella* L.), and 3 as Critically Endangered (*Athamanta cortiana*, *Pinguicula mariae*, and *Vandenboschia speciosa* (Willd.) G.Kunkel).

Despite the presence of 24 invasive alien taxa, only *Ailanthus altissima* (Mill.) Swingle is included in the list of invasive alien species of Union concern under the European regulation UE 1143/2014 and the application regulations UE 2016/1141, 2017/1263, 2019/1262 and 2022/1203. *Buddleja davidii* Franch. is a regionally invasive species widespread in Apuan Alps, and especially problematic in riparian habitats (Gasperini et al. 2020).

Considering that the entire established flora exceeds (or, in the case of some OGU, far exceeds) the expected values, and that the number of alien taxa is lower than expected, the Apuan Alps are objectively rich and natural from a quantitative perspective. Also from a qualitative standpoint, the study area is one of the most important in Italy, with as many as 30 narrow endemics and a significant number of taxa of biogeographical and conservation interest. This underscores the importance of effectively protecting these mountains, which host a unique and rich biodiversity, especially considering that the three richest OGUs are those most impacted by marble quarry activities.

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Supplementary material I

Floristic list and records

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